Multiwavelength three-dimensional 2x2 fiber optic switch structure using small-tilt micromirrors

Riza, Nabeel, Sumriddetchkajorn, Sarun

Nabeel A. Riza, Sarun Sumriddetchkajorn, "Multiwavelength three-dimensional 2x2 fiber optic switch structure using small-tilt micromirrors," Proc. SPIE 3749, 18th Congress of the International Commission for Optics, (19 July 1999); doi: 10.1117/12.354840

Event: ICO XVIII 18th Congress of the International Commission for Optics, 1999, San Francisco, CA, United States

Multiwavelength Three Dimensional 2 × 2 Fiber-Optic Switch Structure using Small Tilt Micro-Mirrors

Nabeel A. Riza and Sarun Sumriddetchkajorn

Photonic Information Processing Systems (PIPS) Laboratory
The School of Optics and CREOL
University of Central Florida, Orlando, FL (riza@creol.ucf.edu)

Abstract

Multiwavelength 2 × 2 fiber-optic switch array retroreflective structure is proposed using a two dimensional array of small ±10° tilt micromirrors. Experimental results at the 1550 nm band indicate a best −23 dB optical crosstalk level.

Recently, the world has seen the rapid deployment of wavelength division multiplexed (WDM) technology for high data rate optical communications. A vital element for further enhancing the versatility of these optical networks is via the deployment of optical switching functions. A key component to realize this goal is the programmable multi-wavelength optical add-drop switch. Recently, several technologies have been proposed to realize this add-drop switch, including two designs using one dimensional (1-D) [1] and two dimensional (2-D) [2] micro-electromechanical systems (MEMS)-based tilt-type mature micromirror technology. The motivation for using MEMS-based micromirror technology include use of low cost large scale microelectronic fabrication techniques, low electric power digital/analog device control, very high degree of polarization insensitivity, broadband multi-wavelength operation, and ultra-compact structures via chip-scale design. Large scale optical networks will deploy N × N switch matrices where wavelengths from any input fiber can be routed to any output fiber. The previous MEMS-based add-drop switches [1,2] cannot perform this task as their structures do not form a 2 × 2 switch that can be further interconnected to form a large switch matrix. Specifically, light input from the add port cannot exit from the drop port. Hence, perhaps for the first time in this paper, we propose and demonstrate how small tilt micromirrors can be used to form a three dimensional (3-D) 2 × 2 optical switching array that can be used to form the all-important large N × N type switch matrix.

Fig.1 shows our multiwavelength 2 × 2 optical switch using highly mature and robust small tilt micromirrors. The key innovation is the use of a specially located fixed mirror to form a symmetric 2 × 2 retroreflective switching structure, where although the mirror tilt angles are small, the beam deflection angles are large, leading to ease in placement of input-output fiber-optics. When the macropixel is set to +10°, the input optical beam from IN1 is reflected back to OUT1 after passing through the optical circulator. At the same time, the input optical beam from IN2 incident on the macropixel at a 40° angle is reflected back to OUT2 by using the fixed mirror. On the other hand, when the macropixel is set to -10°, the input optical beams from IN1 and IN2 are sent to OUT1 and OUT2, respectively, forming our desired 2 × 2 switch. Fig.2 shows a view of the experimental setup where the fiber GRIN-DMD distance is ~ 3.9 mm and the DMD-fixed mirror distance is ~ 18.6 mm, and the WDM MUX/DEMUX devices are not used in the experiment. Our demonstration uses a Texas Instruments (TI) 2-D Digital Micromirror Device (DMD) with small tilt (±10°) micromirrors. Fig.3 shows the TI device closeup of the 16 μm × 16 μm size micromirrors that have the capability to switch in 15 μs (see Fig.4) [3]. Plot 1 shows the measured multi-wavelength (1550-1590 nm) optical crosstalk of our structure, indicating an average optical crosstalk of −22 dB. The average optical loss is 14.83 dB and is limited by the DMD (6.43 dB), optical circulators (1.21 dB), fiber adapters (1.14 dB), and coupling loss (4.45 dB). Substantial loss improvements are possible using larger gold-coated (>95% reflectivity) micromirrors, an antireflection coated hermetic optical window for the device, imaging optics with an f-number > 2.8, and compact 3-D packaging.

[1] J. E. Ford, J. A. Walker, V. Aksyuk, and D. J. Bishop, "Wavelength-selectable add/drop with tilting micromirrors," *IEEE LEOS Annl. Mtg.*, PD2.3, 1997.

[2] N .A. Riza and S. Sumriddetchkajorn, "Fault-tolerant dense multiwavelength add-drop filter with a two-dimensional digital micromirror device," *Applied. Optics*, Vol. 37, No.27, Sept., 1998.
[3] R. L. Knipe, "Challenges of a digital micromirror device^{TM}: modeling and design," *SPIE Proc.*, Vol. 2783, 1996.

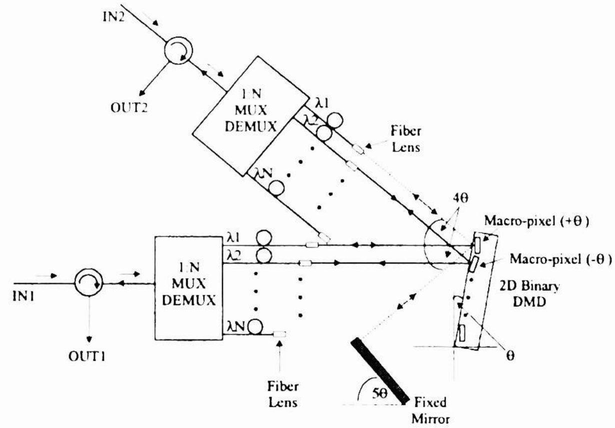


Fig.1: 2-D DMD-based Fiber-Optic 2 × 2 switch.

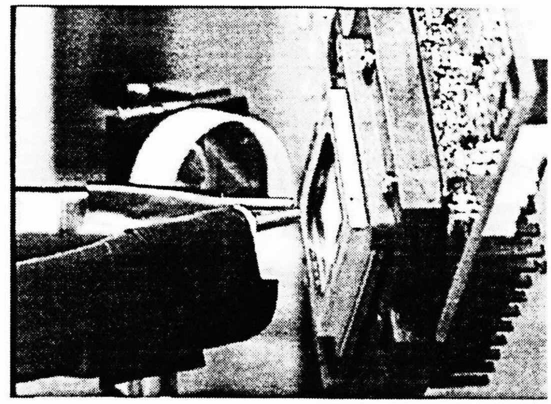


Fig.2: Switch Experimental Setup.

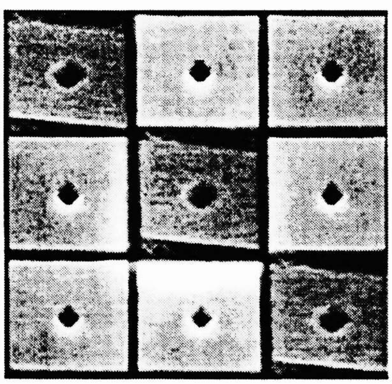


Fig.3: 2-D Micromirror Array.

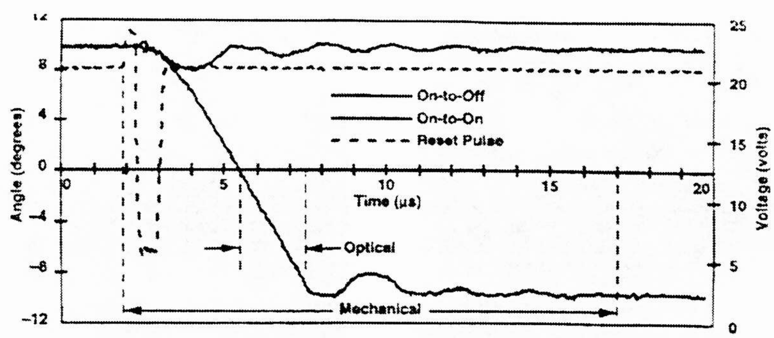
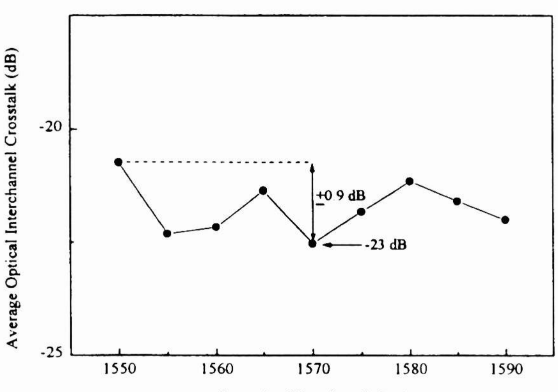
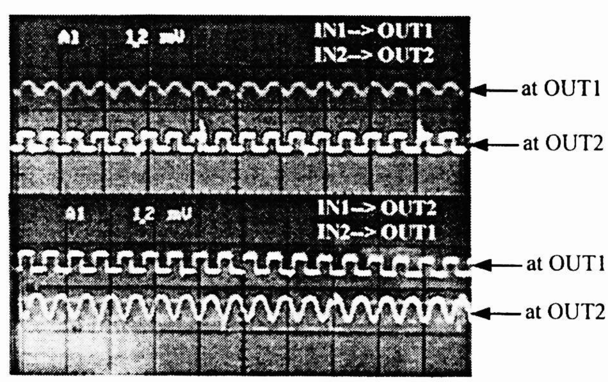


Fig.4: 15 μs Micromirror Switching Speed [3].



Plot1: Crosstalk vs Wavelength.



Plot2: Switch Binary Operation Traces.